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REC'D 13 SEP 2005

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT
(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 4460/10.2	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/PEA/416)	
International application No. PCT/IL2004/000632	International filing date (day/month/year) 14.07.2004	Priority date (day/month/year) 21.07.2003
International Patent Classification (IPC) or both national classification and IPC G06T7/20, G06T11/00		
Applicant PAIEON INC. et al.		
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 8 sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of 3 sheets.</p>		
<p>3. This report contains indications relating to the following items:</p> <p>I <input checked="" type="checkbox"/> Basis of the opinion</p> <p>II <input type="checkbox"/> Priority</p> <p>III <input checked="" type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p>IV <input checked="" type="checkbox"/> Lack of unity of invention</p> <p>V <input checked="" type="checkbox"/> Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p>VI <input type="checkbox"/> Certain documents cited</p> <p>VII <input type="checkbox"/> Certain defects in the international application</p> <p>VIII <input type="checkbox"/> Certain observations on the international application</p>		
Date of submission of the demand 18.05.2005	Date of completion of this report 12.09.2005	
Name and mailing address of the International preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Engels, A Telephone No. +49 89 2399-2042	



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I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, Pages

1-11 as originally filed

Claims, Numbers

1-30 received on 18.05.2005 with letter of 17.05.2005

Drawings, Sheets

1/3-3/3 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
☐ the language of publication of the international application (under Rule 48.3(b)).
☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
☐ filed together with the international application in computer readable form.
☐ furnished subsequently to this Authority in written form.
☐ furnished subsequently to this Authority in computer readable form.
☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

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5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).
(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:
- ☐ the entire international application,
 - ☒ claims Nos. 26-30
because:
 - ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (specify):
 - ☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):
 - ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.
 - ☒ no international search report has been established for the said claims Nos. 26-30
2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:
- ☐ the written form has not been furnished or does not comply with the Standard.
 - ☐ the computer readable form has not been furnished or does not comply with the Standard.

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees, the applicant has:
- ☐ restricted the claims.
 - ☐ paid additional fees.
 - ☐ paid additional fees under protest.
 - ☒ neither restricted nor paid additional fees.
2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is
- ☐ complied with.

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☒ not complied with for the following reasons:

see separate sheet

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

☐ all parts.

☒ the parts relating to claims Nos. 1-25 .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	1-25
	No: Claims	
Inventive step (IS)	Yes: Claims	1-25
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-25
	No: Claims	

2. Citations and explanations

see separate sheet

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Re Item IV

1. Reference is made to the following documents:

D1: EP-A-0 885 594 (MEDINOL LTD) 23 December 1998 (1998-12-23)
D2: NELSON T R ET AL: "Three-dimensional ultrasound imaging" ULTRASOUND IN MEDICINE AND BIOLOGY, NEW YORK, NY, US, vol. 24, no. 9, December 1998 (1998-12), pages 1243-1270, XP004295279 ISSN: 0301-5629
D3: BANKMAN I: "Handbook of Medical Imaging - Processing and Analysis" 2000, ACADEMIC PRESS, SAN DIEGO, LONDON, XP002298756

2. The application lacks unity within the meaning of Rule 13 PCT for the following reasons:

- 2.1 This Authority considers that the following separate inventions or groups of inventions are not so linked as to form a single general inventive concept:

1. Claims 1-25: processing a series of images depicting a moving object subject to composite motion for extracting a cyclic motion component;
2. Claims 26-30: analysis of a graphical representation of a cyclic motion for identifying those images in a series of images that depict an event associated with cyclic motion of a moving object;

- 2.2 The above indicated groups of claims address different problems:

- i. the first group of claims treats the problem of extracting a cyclic motion component from a series of images depicting a moving object subject to composite motion containing both, a cyclic component and a non-cyclic component, and defines a specific method for the extraction.
- ii. the second group of claims treats the problem of identifying those images in a series of images that depict an event associated with cyclic motion of a moving object, in which the way to determine the cyclic motion remains undefined.

- 2.3 The common subject-matter of the above indicated groups of claims is obtaining cyclic motion of a moving object.

As presented in the review paper D2 and the textbook D3 this step is a well-known prerequisite for imaging cardiac dynamics or blood flow. It is conventionally

implemented by analysis of the patient's electrocardiogram signal (ECG) or of the acquired image data of the heart or the blood vessels (see D2, page 1247, chapter "Physiological Synchronization"; D3, page 359, chapter "Dynamic Image Acquisition Techniques").

- 2.4 Hence, the above indicated groups of claims do not contain any corresponding special technical features in the sense of Rule 13 PCT, i.e. they are not linked by a single general inventive concept and, thus, lack unity.

Re Item V

1. Independent **claims 1 and 24** are not clear and, thus, do not meet the requirements of Article 6 PCT.

As a proportional part of the non-cyclic component is computed for each of the at least one pair of successive images, it should be made clear that the **subtracting** of the proportional part from the composite motion is **also performed for each of the at least one pair of successive images**. Since the composite motion is already defined as a series of vectors, such clarification would also clearly define the nature of the resulting cyclic component as a series of vectors.

2. Clarification according to the above objection provided, the present application meets the criteria of Article 33(1) PCT, because the subject-matter of independent **claims 1 and 24** is new in the sense of Article 33(2) PCT and involves an inventive step in the sense of Article 33(3) PCT.

The discussion will be limited to method claim 1, since system claim 24 defines the same features using the same terminology.

The invention as defined in claim 1 relates to extracting the cyclic motion component from a series of images of a moving object subject to composite motion containing cyclic and non-cyclic motion, e.g. in medical imaging of the heart and angiography.

D1 as closest prior art relates to the processing of a series of intravascular ultrasound images (see abstract) inter alia for stabilization of the images, i.e. for motion

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compensation before display. The motion to be compensated is caused by "beating of the heart, blood and/or other fluid flow through the lumen, vasomotion, forces applied to the physician, and other forces caused by the physiology of the patient", i.e. the motion is a composite motion containing at least one cyclic component due to the heart beat and a non-cyclic component due to other forces (see abstract; page 2, lines 42-50). During the stabilization process the composite motion is evaluated as a series of shifts between successive images (see page 4, lines 45-50). The shift is accumulated, i.e. integrated, over a cardiac cycle in order to monitor drift (see page 15, lines 11-14), drift being "a process in which implemented shifts accumulate and produce a growing shift whose dimensions are significant in relation to the entire image or display. Drift may be a result of inaccurate shift evaluation or non-transverse inter-image motion at some part of the cardiovascular cycle" (see page 10, lines 38-44). Hence, in a case where shift evaluation is correct, the drift represents a non-transverse inter-image motion at some part of the cardiovascular cycle, which is a non-cyclic motion.

However, the claimed invention differs from D1 in that

- i. the non-cyclic motion component contained in the composite motion is defined as **consistent** and of a lower motion frequency than the cyclic component - it is not a "non-transverse inter-image motion at some part of the cardiovascular cycle";
- ii. a **proportional part of the non-cyclic component** is computed for each of the **at least one pair of successive images** in the series of images and the proportional part is **subtracted from the composite motion** for each of the at least one pair of successive images so as to obtain the cyclic component.

The problem is, thus, to explicitly extract the cyclic component from the composite motion that contains an additional non-cyclic, consistent motion component of a lower motion frequency than the cyclic component.

The solution to this problem as presented in claim 1 is neither disclosed nor rendered obvious in any of the prior art documents of the International Search Report. In particular, the solution is not rendered obvious by D1, since the non-cyclic motion component in D1 is not of a consistent nature, so that subtracting proportional parts of it from the composite motion would not lead to a meaningful result.

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Hence, claim 1 is inventive.

3. **Claims 2-23 and 25** are dependent on claims 1 and 24 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

Further Remarks

1. The wording of the claims is inconsistent in that **claims 1, 23, 24 and 25** refer to a "*motion cycle*" while the remainder of the claims and the description refer to a "*cyclic period*" (Article 6 PCT).
2. Independent **claims 1 and 24** are not in the two-part form in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, with those features known in combination from the prior art (D1) being placed in the preamble (Rule 6.3(b)(i) PCT) and with the remaining features being included in the characterising part (Rule 6.3(b)(ii) PCT).
3. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D1 and D2 is not mentioned in the description, nor are these documents identified therein.

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CLAIMS:

- 1 A method for obtaining a cyclic motion within a series of images depicting a moving object subject to composite motion containing a cyclic component having a motion cycle and a non-cyclic consistent component of a lower frequency than the cyclic component, the method comprising:
 - (a) computing the composite motion between at least one pair of successive images, the composite motion represented by at least one vector;
 - (b) computing the non-cyclic component as the integral of the composite motion over a motion cycle;
 - (c) computing a proportional part of the non cyclic component for each of the at least one pair of successive images; and
 - (d) subtracting the proportional part of the non-cyclic component from the composite motion so as to obtain the cyclic component.
- 2 The method according to claim 1, wherein a cyclic period of the cyclic motion component is computed using spectral analysis.
- 3 The method according to claim 1 or 2, wherein the composite motion is determined by optical flow.
- 4 The method according to claim 1 or 2, wherein the composite motion is determined using phase correlation of said images.
- 5 The method according to any of claims 1 to 4, where cyclic motion values are used for evaluating performance of a body organ.
- 6 The method according to claim 4, when used in a cardiac application to evaluate heart performance.
- 7 The method according to claim 6, when used for Ejection Fraction analysis.
- 8 The method according to claim 6, when used for Left Ventricular analysis.
- 9 The method according to claim 6, when used for Wall Motion analysis.
- 10 A method for identifying an image depicting an event associated with cyclic motion, the method comprising:
 - (a) computing the cyclic motion according to the method of any one of claims 1 to 4;
 - (b) using a graphical representation of the cyclic motion to identify all images matching said event; and

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(c) selecting one of said images.

- 11 The method according to claim 10, wherein the selected image is closest to a predetermined approximation.
- 12 The method according to claim 10 or 11, wherein the event is least motion.
- 13 The method according to claim 12, for selecting angiographic images to participate in three-dimensional reconstruction of coronary vessels.
- 14 The method according to claim 13, including deriving cycle period and approximation for least-motion image from an analysis of an ECG signal.
- 15 The method according to claim 13 or 14, including distinguishing the end-diastole instance from the end-systole instance by the state of coronary vessel – maximal spreading versus minimal spreading, respectively.
- 16 The method according to any one of claims 5 to 15 when used for selecting optimal image or images for QCA analysis.
- 17 The method according to any one of claims 5 to 15 when used for selecting optimal image or images for IVUS analysis.
- 18 The method according to any one of claims 5 to 15 when used for selecting optimal image or images for LVA analysis.
- 19 The method according to any one of claims 5 to 15 when used for selecting optimal image or images for Wall Motion analysis.
- 20 The method according to any one of claims 5 to 15 when used for CT reconstruction.
- 21 The method according to any one of claims 5 to 15 when used for MRI reconstruction.
- 22 The method according to any one of claims 5 to 15 when used for PET reconstruction.
- 23 The method according to claim 1 wherein the series of images comprises an at least one series of N images acquired during a motion cycle, each frame having an index i within the motion cycle, $i=1 \dots N$, and wherein the proportional part of the non cyclic component for each of the at least one pair of successive images $i-1$ and i is determined by dividing the non cyclic component by N and multiplying by $i-1$.
- 24 A system for obtaining a cyclic motion within a series of images depicting a moving object subject to composite motion containing a cyclic component having a motion cycle and a non-cyclic

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consistent component of a lower frequency than the cyclic component, the system comprising:

a composite motion unit for computing the composite motion between at least one pair of successive images, the composite motion represented by at least one vector;

a non-cyclic motion unit for computing the non-cyclic component as the integral of the composite motion over a motion cycle;

a proportional part unit for computing a proportional part of the non cyclic component for each of the at least one pair of successive images; and

a subtraction unit for subtracting the proportional part of the non-cyclic component from the composite motion so as to obtain the cyclic component.

25 The system according to claim 24 wherein the series of images comprises an at least one series of N images acquired during a motion cycle, each frame having an index i within the motion cycle, $i=1 \dots N$, and wherein the proportional part of the non cyclic component for each of the at least one pair of successive images $i-1$ and i is determined by dividing the non cyclic component by N and multiplying by $i-1$.

26 A system for identifying an image depicting an event associated with cyclic motion, the system comprising:

a cyclic motion unit for computing the cyclic motion and deriving data representative of a graphical representation thereof,

an image identification unit responsive to said data representative of a graphical representation of the cyclic motion for identifying all images matching said event, and

an image selection unit for selecting one of said images.

27 The system according to claim 26, wherein the image identification unit is adapted to identify minimal cyclic motion.

28 The system according to claim 27, wherein the image selection unit is adapted to select angiographic images to participate in three-dimensional reconstruction of coronary vessels.

29 The system according to claim 28, including an ECG analyzer for deriving cycle period and approximation for least-motion image from an analysis of an ECG signal.

30 The system according to claim 28 or 29, including an image processing unit coupled to the image selection unit for distinguishing the end-diastole instance from the end-systole instance by the state of coronary vessel – maximal spreading versus minimal spreading, respectively.